Near -Infrared Tunable Diode Laser Diagnostics in Laboratory and Real-Scale Inhibited Flames

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ABSTRACT: Near-infrared tunable diode lasers (NIRTDL's) are used to measure fuels, oxidizers, and combustion products during suppression of laboratory and real-scale flames by Halon 1301 (CF_3Br) and FM-200 (C_3F_7H).

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The goal of this research project is to develop and demonstrate/validate new laser-based instrumentation for the measurement of concentrations of candidate suppressants, oxygen, fuels, and combustion byproducts during suppression of flames and explosions. Time resolved measurement of concentrations of suppressants, oxygen, fuels, and combustion byproducts serve as a check on the repeatability of the tests and help determine why a suppressant is behaving well or poorly in a given full-scale suppression test.

The approach used in the investigation of gas species produced during suppression of crew and engine compartment fires involves a close interaction between laboratory based combustion diagnostics facilities currently in place at ARL and similar, ruggedized, facilities in place at ATC. Instrument utility, response, and quantitative calibration are performed at ARL prior to application of a particular technique to large scale fire scenarios. This protocol has been used successfully for the quantification of HF gas produced during chemical inhibition of JP-8 fuel pool fires[1].

Key benefits to implementation of laser-based sensing devices derive from real-time sensing and the ability to use multiple sensors from a single laser source. Real time sensing is important because it provides information on how and at what rate fuel and oxidizer are consumed, the time required following agent release for suppressant to be effective, and the rate at which toxic gases are produced during a suppression event. Typically, fire suppression on-board military vehicles is accomplished within 250 milliseconds of fire detection. Gases measured using NIRTDL absorption spectroscopy include HF, CO, CH_4, O_2, NO_2, and H_2O. Use of multiple sensors, enabled because the lasers and detectors are fiber coupled, is required because of the need to know how well a given agent suppresses a fire at different locations within the vehicle. Together, the use of real-time sensing and multiple sensor measurement provide a means to judge why a suppressant behaves the way it does in different fire scenarios.

Examples will be presented of NIRTDL absorption spectroscopy of several gases in laboratory-scale, atmospheric pressure opposed flow flames and in full scale testing on board military vehicles (see Figure 1).

1. Applied Optics, vol. 35, p4004 (1996).

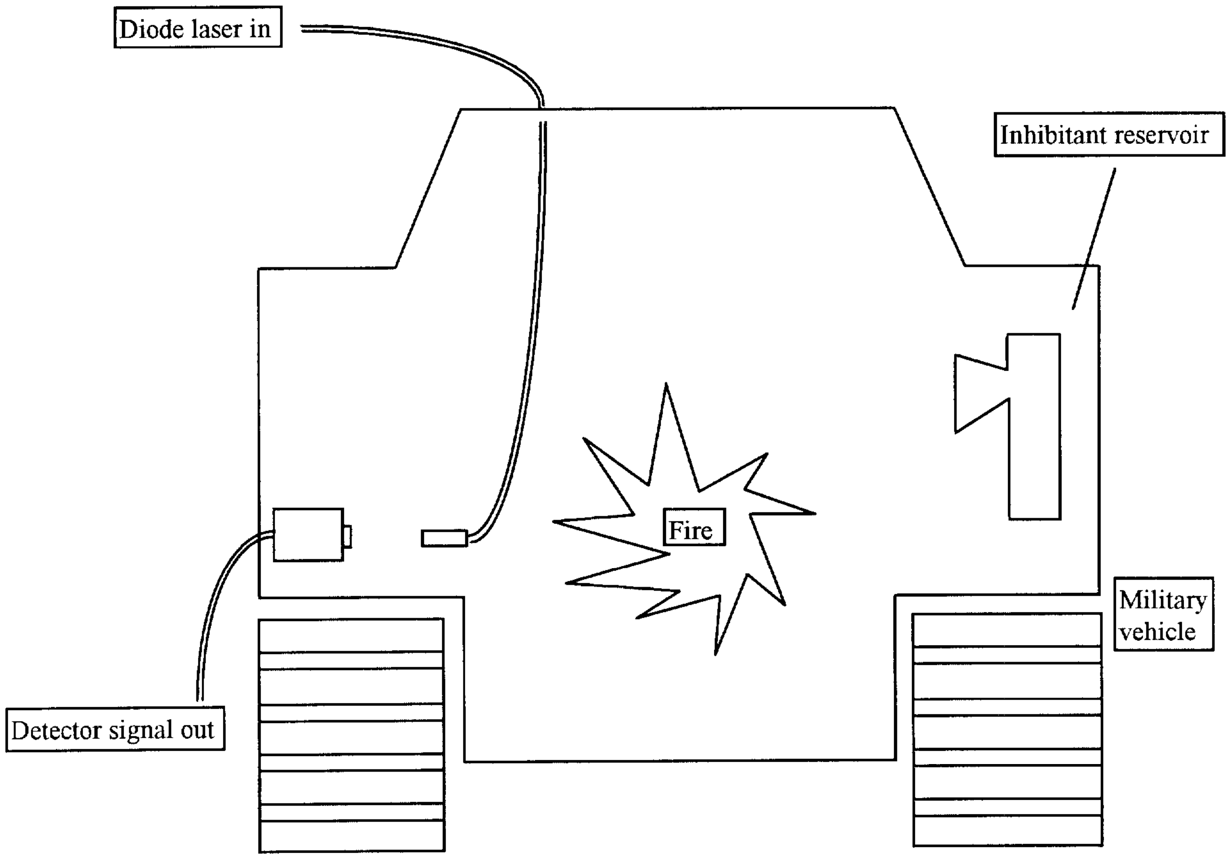

Figure 1: Schematic of experimental setup for measurement of combustion species produced during suppressant testing on board military vehicles.